SCIENCE

NEW YORK, MAY 22, 1891.

THE TEACHING OF SCIENTIFIC METHOD.[1]

THE title of the address which I am privileged to deliver this evening has been advisedly chosen, in order to mark the contrast between the teaching of what is commonly called "science" and the teaching of "scientific method." It is, I think, to the failure to discriminate between these that the delay of which we so bitterly complain in introducing experimental studies into schools generally is large attributable.

For years past the educational world has been witness of conflicts innumerable. Its time-honored and most cherished dogmas and practices have been subjected to severely searching criticism, and it cannot be denied that they have oftentimes emerged from the battle in a terribly mangled condition; nevertheless they have hitherto manifested a marvellous recuperative power. Modern subjects, especially experimental science, have as yet barely obtained a foothold in our schools, and their educational effect has been scarcely appreciable; nay, it is even said, and probably with too much of truth, that the results under our present — may I not say — want of system are inferior to those obtained in the purely classical days of yore, when the scholars' efforts were less subdivided, when fewer subjects claimed their attention. The net upshot of discussion simply has been that we are intensely dissatisfied with our present position, and that we realize that some change has to be made. What that change is, we are not yet agreed. This, after all, is a very healthy state to be in, and one which necessarily must precede the construction of a satisfactory programme of studies suited to the vastly changed conditions under which the work of the world has been carried on since those two potent agents, steam and electricity, have assumed sway.

In setting our house in order, one great difficulty arises from the multitude of counsellors. Every subject in turn asserts its soul-saving power, and puts forth its claim on a portion of the school time. An infinite number of suggestions are made. Who is to arbitrate in so difficult a case? Certainly, the more I study the educational problem, the more I realize the extraordinary difficulties which it presents. We are not all cast in one fixed mould, and cannot all be made alike. Educational rules must necessarily be made infinitely elastic, and educational success can only be achieved by the elastic administration of rules.

But are those who are charged with the conduct of so difficult a mission in any way specially prepared for the campaign? Suppose at a largely attended representative meeting of British teachers some one were to discourse in most eloquent terms of the beauties of the Chinese language, and were to affirm in the most positive manner possible that no other language offered the same opportunity of inculcating lessons of the highest import, what would be the result? Few, if any, present would know a word of the language; and therefore, although all might agree that they had listened to a most learned and interesting discourse, the effect would be ephemeral, and the advice given would be wholly disregarded by the majority. Never having had occasion to study the language, they probably would mentally set down the lecturer as a *doctrinaire*,— as a member of that troublesome and objectionable class, the enthusiasts, who are always interfering with other people's business and trying to lead them to mend their ways. Some few might think it politic to include Chinese in their school programme. These would either purchase a "Reader," and endeavor to master the subject themselves sufficiently to impress a smattering of information on a limited number of pupils in perhaps the higher forms in their schools, or would engage a young fellow fresh from the university as teacher, who had little more than mastered the principles of the Chinese alphabet, but was considered capable of any thing because he had taken a good degree. I very much fear that the treatment which I picture as accorded to my hypothetical subject, Chinese, is very much the kind of treatment meted out to experimental science in most schools. In the majority of cases it has been included in the programme because it has become fashionable and is a subject in which public examinations are held, more or less under compulsion, and without real belief in its worth or efficacy as an educational instrument. It is not surprising, therefore, that the results have been so unsatisfactory.

Two causes appear to me to operate in retarding educational progress. In the first place, our schools, with scarcely an exception, are controlled by our ancient universities; and these, I think, are not improperly described as, in the main, classical trades-unions. The majority of those who pass through their courses are required only to devote their attention to purely literary studies, and, unless by accident, they acquire no knowledge of the methods of natural science: consequently, having no understanding of, they exhibit no sympathy with, its aims and objects. It is a strange fact that so limited and non-natural a course of training should alone be spoken of conventionally as "culture," and that it should count as no sin to be blind to all that is going on in the world of nature around us, and to have no appreciation or understanding of the changes which constitute life, — no knowledge of the composition and characters of the materials of the earth on which we dwell. As the entire body of teachers in the more important of our schools are university men, and the examples which such schools set permeate into and pervade schools generally, the result of the introspective system of training followed at our universities is disastrous. That the effect of a change in the present university system on scholastic opinion and practice would be far-reaching, has been clearly realized. In proof of this, I may again cite remarks made by the present head master of Rugby, formerly head master of Clifton College, which I quoted in my address to the Chemical Section of the British Association at Aberdeen in 1885: they were made at a meeting of convocation at Oxford a few months previously. Dr. Percival said, "If twenty years ago this university had said, from this time forward the element of natural science shall take their place in responsions, side by side with the elements of

[1] Paper read by Professor Henry E. Armstrong at a meeting of the British College of Preceptors, April 8, 1891.

mathematics, and shall be equally obligatory, you would long ago have effected a revolution in school education." Reading between the lines, I imagine that Dr. Percival would imply that such action of the university would have led schools generally to pay attention to natural science, just as they do to mathematics, and that the general public would thereby also have been led to appreciate such studies. Charles Kingsley gave utterance to similar thoughts when he said, "I sometimes dream of a day when it will be considered necessary that every candidate for ordination should be required to have passed creditably in at least one branch of physical science, if it be only to teach him the method of sound scientific thought." Evidently Kingsley was of opinion that the teaching of his day was not always conducive to habits of "sound scientific thought." Has it been much improved in the interval? There are a few who cannot realize what would be the effect of neglecting to teach the elements of mathematics: Dr. Percival's advice that the elements of natural science should be made equally obligatory is therefore pregnant with meaning. All can imagine what difficulty would be created at Cambridge, for example, if those who went up wishing to study mathematics had no acquaintance with even the first four rules of arithmetic, but such is the position, owing to the neglect of natural science in schools, in which those of us find ourselves who are called on to teach science in colleges and at the universities; and the result is, that the time which should be devoted to the study of the higher branches of a subject is wasted in teaching elementary principles, more often than not, to unwilling minds unprepared to assimilate knowledge involving studies of an entirely novel character.

But, beyond the difficulties created by the low standard of scholastic and public opinion as regards natural science, there is a second retarding cause in operation, for the existence of which we teachers of natural science are in a great measure responsible, and which it behooves us to remove. I refer to the absence of any proper distinction between the teaching of what is commonly called "science" (i.e., facts pertaining to science) and the teaching of scientific method. The dates at which our various kings reigned, the battles they fought, and the names of their wives, are facts pertaining to history, and it is not so very long since such facts alone were taught as history. Nowadays such facts are but incidentals in a rational course of historical study, and it is clearly realized that the great object is to inculcate the use of such facts, — the moral lessons which they convey. "And if I can have convinced you that well-doing and ill-doing are rewarded and punished in this world, as well as in the world to come, I shall have done you more good than if I had crammed your minds with many dates and facts from modern history" (conclusion of Kingsley's lectures on America at Cambridge in 1862), are words which aptly convey an idea of one of the chief purposes gained in teaching history, and by which the methods of teaching it are being moulded. In like manner, to inculcate scientific habits of mind, — to teach scientific method, — we must teach the use of the facts pertaining to science, not the mere facts. Again, in teaching history in schools, we recognize that the subject must be broadly handled, and attention directed to the salient points which are of general application to human conduct: the study of minutiæ is left to the professed historian. But the very reverse of this practice has been followed, as a rule, in teaching natural science in schools. At various times during recent years — at the Educational Conference held at the Health Exhibition in 1884, and at the British Association meeting in 1885 — I have protested against the prevailing system of teaching chemistry, etc., to boys and girls at school as though the object were to train them all to be chemists; and I have also protested against the undue influence exercised by the specialist, — an influence which he has acquired in consequence of the inability of the head of the school to criticise and control his work. I refer here as much to the examiner as to the teacher; indeed, more. It appears to me to be our duty to regard all questions relating to school education from a general point of view, to consider what is most conducive to the general welfare of the scholar; and in allowing the specialist access to the school, the greatest care must be taken that the subject treated of is dealt with in a manner suited to the requirements of the scholars collectively. It is only in the case of technical classes that supreme control can be vested in the specialist.

In order that we may be in a position to usefully criticise the educational work which is being done, and the proposals brought forward, it is essential to arrive at a clear understanding of the objects to be achieved. Much of the work in a school is done with the object of cultivating certain arts (mechanical arts, we may almost call them), — the art of reading, the art of writing, and the art of working elementary mathematical problems, until the operations involved are efficiently performed in an automatic manner. An elementary acquaintance with these arts having once been gained, all later studies may be said to originate naturally in them, — both those which lead to the acquisition of knowledge, and those which have for their ultimate object the development and training of mental faculties. The character and extent of these later studies is subject to great variation, according as individual requirements, opportunities, and mental peculiarities vary; but the variation is not usually permitted to take place until a somewhat late period in the school career. We recognize, in fact, that in the case of every individual the endeavor must at least be made to develop the intellectual faculties coincidently in several directions. The question at issue at the present moment, I take it, is the number of main lines over which we can and are called on to travel. Hitherto only two have been generally recognized, — the line of literary studies, and the line of mathematical studies; but those of us who advocate the claims of natural science assert that there is a third, and that this is of great importance, as a large proportion of the work of the world is necessarily carried on over it. We assert, in fact, that however complete a course of literary and mathematical studies may be made, it is impossible by attention to these two branches of knowlege to educate one side of the human mind, — that side which has been instrumental in erecting the edifice of natural science, and in applying science to industry: the use of eyes and hands. I never tire of quoting from Kingsley's lecture to the boys at Wellington College (*Letters and Memories of his Life*, 3d abridged edition, p. 146, Kegan Paul & Co.): it puts the case into a nutshell: —

"The first thing for a boy to learn, after obedience and morality, is a habit of observation, — a habit of using his eyes. It matters little what you use them on, provided you do use them. They say knowledge is power, and so it is, but only the knowledge which you get by observation. Many a man is very learned in books, and has read for years and years, and yet he is useless. He knows *about* all sorts of things, but he can't *do* them. When you set him to work, he makes a mess of it. He is what you call a pedant, because he has not used his eyes and ears. . . . Now, I don't

mean to undervalue book-learning; . . . but the great use of a public school education to you is, not so much to teach you things as to teach you how to *learn*. . . . And what does the art of learning consist in? First and foremost in the art of observing; that is, the boy who uses his eyes best on his books, and *observes* the words and letters of his lesson most accurately and carefully, that is the boy who learns his lesson best, I presume. . . . Therefore I say that everything which helps a boy's powers of observation helps his power of learning; and I know from experience that nothing helps that so much as the study of the world about you."

Literary and mathematical studies are not a sufficient preparation in the great majority of cases for the work of the world: they develop introspective habit too exclusively. In future, boys and girls generally must not be confined to desk studies; they must not only learn a good deal about things, they must also be taught how to do things, and to this end must learn how others before them have done things by actually repeating — not by merely reading about — what others have done. We ask, in fact, that the use of eyes and hands in unravelling the meaning of the wondrous changes which are going on around us in the world of nature shall be taught systematically in schools generally; that is to say, that the endeavor shall be made to inculcate the habits of observing accurately, of experimenting exactly, of observing and experimenting with a clearly defined and logical purpose, and of logical reasoning from observation and the results of experimental inquiry. Scientific habits and method must be universally taught. We ask to be at once admitted to equal rights with the three R's: it is no question of an alternative subject. This cannot be too clearly stated, and the battle must be fought out on this issue within the next few years.

The importance of entering on the right course when the time comes that this claim is admitted — as it inevitably must be when the general public and those who direct our educational system realize its meaning — cannot be exaggerated. The use of eyes and hands — scientific method — cannot be taught by means of the blackboard and chalk, or even by experimental lectures and demonstrations alone: individual eyes and hands must be actually and persistently practised, and from the very earliest period in the school career. Such studies cannot be postponed until the technical college or university is reached: the faculties which can there receive their highest development must not have been allowed to atrophy through neglect during the years spent at school. This is a point of fundamental importance. At school the habit is acquired of learning lessons, of learning things from books; and after a time it is an easy operation to a boy or girl of fair mental capacity, given the necessary books, to learn what is known about a particular subject. One outcome of this, in my experience, particularly in the case of the more capable student, is the confusion of shadow with substance. "Why should I trouble to make all these experiments which take up so much time, which require so much care, and which yield a result so small in proportion to the labor expended, when I can gain the information by reading a page or so in such and such a text-book?" is the question I have often known put by highly capable students. They fail to realize the object in view, — that they are studying method; that their object should be to learn how to make use of text-book information by studying how such information has been gained; and to prepare themselves for the time when they will have exhausted the information at their disposal, and are unprovided with a text-book, when they will have to help themselves. I am satisfied that the one remedy for this acquired disease is to commence experimental studies at the very earliest possible moment, so that children may from the outset learn to acquire knowledge by their own efforts; to extend infantile practice — for it is admitted that the infant learns much by experimenting — and the kindergarten system into the school, so that experimenting and ob serving become habits. The vast majority of young children naturally like such work, and it is to be feared that our system of education is mainly responsible for the decay of the taste with advancing years.

No doubt, just as literary excellence may be attained through the agency of one or other of several languages, scientific method may be inculcated in a variety of ways; and we may expect that, looking at the problem from various points of view, teachers will ere long devise courses suited to the requirements of scholars of different types. My views have been somewhat fully set forth in the "Reports to the British Association of the Committee on the Present Methods of Teaching Chemistry" (B. A. Report, 1888, 1889, 1890); but it is perhaps not superfluous to mention that the draft schemes which I have prepared are but outlines for the consideration of the competent teacher. On the present occasion, I may fitly bring my address to a conclusion by calling attention to a few simple experiments in illustration of the method of teaching of which I am an advocate. [The remaining portion of the address was illustrated with experiments.]

In the first place, I hold that, in order that children may acquire scientific habits, they should be led to look around them and take note of the various objects which present themselves to view. Lists of such objects having been prepared, their several uses having been as far as possible realized, and much simple information as to their origin, etc., having been imparted by reading lessons and practical demonstrations, a stage will be reached at which the children can themselves begin to determine the properties of common objects, generally by measurement. The measurement lessons in the first instance may be of the simplest kind. Much may be done with the aid of a boxwood scale divided into tenths of an inch on the one edge, and into millimetres on the other. With the aid of such a scale, children may learn to measure accurately, and may be taught the use of decimals and the relation between the English and the metric system. Obviously such work might well form part of the arithmetic lesson, and there can be no doubt that "practical arithmetic" lessons would often be far more easily mastered and be more interesting than are the dry problems of the books. It is easy also to take advantage of the opportunity afforded by these lessons to impress useful information of quite another character by such an exercise as the following, for example, which I suggest, however, merely by way of illustration, and not as in any sense novel: "Third-class passengers usually pay fare at the rate of one penny per mile. Ascertain from a railway time-table (Bradshaw) the fares to a number of the chief towns in England, Wales, and Scotland from London, and then calculate the distances in miles and kilometres (1 kilometre is equal to 1,000 metres)."

In the next place, the measurement lessons may take the form of lessons in weighing. I am of opinion that the disciplinary effect of teaching chlidren to weigh exactly cannot be overestimated. It matters little what is weighed, provided that the weighing be done as accurately as the balance at disposal permits. Professor Worthington, in his invalua-

ble book "Physical Laboratory Practice" (Rivington's), has advocated the use of a simple balance costing only four shillings. However suitable this may be for demonstrating certain principles in physics, its use is to be entirely deprecated, in my opinion, for the purpose I have in view. I would urge most strongly that a far better instrument be procured, such as one of Becker's (of Rotterdam; English agents, Townson and Mercer) balances, costing, with suitable weights, about £3. In using such a balance, care has to be taken in releasing the beam and in bringing it to rest again; the pans must not be allowed to swing from side to side, but must be made to move gently up and down; the weights must be lifted on and off the pans with pincers, not touched by the fingers, so as to preserve them untarnished; and the weighing can, and in fact must, be made with considerable exactness. Finding that so many precautions have to be taken, and being severely reprimanded if careless in using such a balance, the child acquires a wholesome respect for the instrument, and soon becomes careful and exact. Weighing with the four-shilling pair of scales can afford no such discipline: their use in no way serves to correct the tendency (to quote a schoolboy phrase) to "muck about," unfortunately inherent in youth,—a tendency which can, I believe, be more successfully counteracted by proper measurement lessons than in any other way. The objection made to the purchase of so costly a balance for school use, I hold to be quite unwarrantable. Schools have no hesitation in charging for the use of books, and a charge of half a crown a year would more than cover their cost, if it were not possible to provide weighing appliances as part of the school furniture. I have been told that you cannot trust boys to use so delicate an instrument as that I advocate; and probably you cannot, if you wait until they have grown past control; but I believe that the difficulty will not arise if the instruction be given to children when quite young.

Having learned to measure and weigh exactly, the children may be set to examine things generally. One of the best exercises that can be devised consists in weighing and measuring rectangular blocks of different kinds of wood, and then reducing the results so as to ascertain the weights of equal bulks. In this way the child is led to realize that in the several varieties different amounts of the wood-stuff are packed in the same space; that some woods are denser than others. The relative densities may then be calculated, taking the lightest as standard; and also their densities, i.e., the quantity of wood-stuff in the unit of volume, choosing several different units both of mass and of volume. The data thus obtained may be made use of in many ways, e.g., in setting arithmetical problems as to the weights of planks, etc., of various sizes; and lessons may at the same time be given as to the uses and characters of the different woods, the trees from which they are obtained, etc. In a similar manner, common liquids may be studied comparatively with the aid of a simple "density" bottle, constructed by filing a nick down the glass stopper of an ordinary two ounce narrow-mouth bottle, which may also be used in determining the relative density of solids of irregular shape. Children are thus put in possession through their own efforts of a series of numerical data whereby various materials may be characterized, and can be led to realize that it is possible to convey exact information by quoting these numerical data.

It is almost superfluous to point out that when the use of the balance has been learned, a stage is reached at which the study of levers and other simple mechanical powers may very properly begin; and that the determinations of densities of liquids serve as an appropriate introduction to hydrostatics.

Measurements of another kind, which afford most valuable training, are those effected with the aid of a thermometer. It is most important that the use of this instrument should be generally understood, especially by women. It is astonishing how few people know the temperature at which water boils, and how mysterious an instrument to most is the clinical thermometer. Practice having thus been acquired in making measurements, and considerable knowledge having been gained of properties of common materials, I would advocate the quantitative study, especially by girls, of the effect of heat on vegetable and animal food materials, and subsequently on earthy substances and metals. Such exercises would serve as an appropriate introduction to the study of chemical change, which at this stage should be entered on more particularly with the object of developing the reasoning powers. I propose to give two examples by way of illustration. The one relates to the discovery of the composition of air; the other, to the discovery of the composition of chalk.

In considering air, it is the practice with most teachers, I believe, to explain, and in some cases demonstrate, how oxygen may be prepared, and how brilliantly many substances burn in it; air is then stated to be a mixture of oxygen with nitrogen in certain proportions, and certain proofs of this statement are advanced. Although much interested in the statements, and delighted at witnessing the firework displays which attend combustion in oxygen, the young student is not much the wiser for such lessons: a certain amount of "prepared food" has been put into his or her mouth, but no understanding acquired as to how it has been prepared, or whence it came. I advocate an entirely different course: I would not say one word as to what air is, or as to its having any thing to do with combustion, but would lead the scholar to discover that air is concerned in many common changes which apparently occur spontaneously, and to understand how the discovery that this is the case is made. Having directed attention to the manner in which animal and vegetable substances gradually decay, and are destroyed when burned, and to the rusting of iron, etc., I would propose that such changes should be experimentally investigated, and suggest that as iron rusts so readily when moist, the rusting of iron should be first examined: then would come the question, "But how is this to be done?" Having become so habituated to the use of the balance, and to express facts by numerical data, the student would appreciate the advice, "Let us see whether the balance will not aid us; let us endeavor to ascertain whether the iron gains or loses in weight during rusting." A clock-glass or saucer is therefore weighed; some iron borings or nails are put upon it, and the weight ascertained; and, as iron is known to rust more rapidly when wet, the borings or nails are wetted and set aside to rust. After several days, the rusted iron is dried in an oven and weighed: it is found that the weight has increased, whence it follows that something from somewhere has been added to the iron. Thus a clew has been gained, and, following the example of the detective in search of a criminal, this clew is at once followed up. "Where did the something come from? It might be the water; but is there no other possible 'offender'? Yes, the iron rusted in air." This suggests the experiment of exposing wet iron in air in such a way as to ascertain whether the air is concerned in the rusting. Some borings are tied up in a piece of muslin, and the bag is hung from one end of a piece of stout wire,

bent round at the opposite end, so as to form a foot; the wire is set upright in a dish full of water, and a large pickle-jar is inverted over it, with its mouth in the water. The iron is thus shut up over water along with air. Gradually the iron rusts, and concurrently the water rises in the jar, showing that the air is concerned, as no rise is observed in a comparison experiment without the iron. But after a time the water ceases to rise: measurement shows that only about one-fifth of the air disappears. Clearly, therefore, the air is concerned. The experiment is repeated, and the same result obtained; fresh iron is put into the residual air, and still no change results: hence it follows, that, although the air plays a part in the rusting of iron, the air as a whole is not active, but only one-fifth part of it, which serves to suggest that the air is not uniform, but has parts. Consider the importance of the lesson thus learned, the number of discoveries made by a few simple quantitative experiments, the insight into exact method which is gained by a thoughtful worker.

To pass to my second example, — the discovery of the composition of chalk. How is this to be effected? I would call attention to what is known about chalk by people generally, — what it is like, where it occurs, and what it is used for, — and ask whether there is no well-known fact connected with chalk which will serve as a clew, and enable us to apply our detectives' method. One of the great uses of chalk is for making lime, which is got by burning chalk. Is there any thing known about lime which shows that it differs from chalk? Yes, when wetted, it slakes and much heat is given out, while chalk is not altered by wetting; when the experiment is made quantitatively, lime is found to increase about 33 per cent in weight on slaking. Let us then study the conversion of chalk into lime by burning, and, as our unaided eyes tell us nothing, let us call in the aid of a balance. A weighed quantity of chalk is strongly heated, and is found to grow lighter; after a time, no further loss is observed, and, when this is the case, the loss amounts to, say, about 43 per cent; on repeating the experiment, the same result is always obtained, and therefore it cannot be an accident that the loss amounts to only about 43 out of every 100 parts of chalk. What conclusion are we to draw? Evidently that the stuff composing chalk consists of lime-stuff plus something else which is driven off when the chalk is burned. What is this something? Can't we catch it as it is given off? (We can, but the experiment is difficult, requiring special appliances, owing to the high temperature required to burn chalk in a close vessel). If not, is there no other clew which can be followed? Yes, there is. It is to be supposed that at an earlier stage in the experiments, attention will have been directed to the way in which discoveries were made in early times; to the fact that various substances were found to act upon each other, giving new substances; and that when a new substance was discovered its action on the previously known substances was studied; that in this way various acids were discovered; and that it was found out that these were powerful solvents of metals, earthy substances, etc., of chalk, among other substances. What happens to chalk when thus dissolved in an acid? The experiment is tried, and it is found that an air-like substance or gas escapes as the chalk dissolves. How does lime behave with acid? It is found on trial to dissolve, but no gas is given off. May it not be, then, that the gas which is given off when chalk becomes lime is also given off when chalk is acted on by acid? Let us find out how much gas is given off in this latter case. A weighed quantity of chalk is dissolved in acid and the gas measured, a simple apparatus being used, like that figured in the last "British Association Report" (*Nature*, April 23, 1891). It is found, when several experiments are made, that, on the average, about 22,000 cubic centimetres of gas are given off per 100 grams of chalk; and chalk is thus shown to be characterized not only by the percentage of lime which it yields, but also by the amount of gas which it affords when dissolved in acid.

What is the weight of the gas that escapes? The experiment is carried out (by means of a very simple apparatus), and the all-important discovery is made that the weight of the escaping gas is just about what was lost on burning chalk. There can be little doubt, therefore, that the gas thus studied is "the something" which is given off when chalk is burned. If so, perhaps it may be possible to reassociate this gas with lime, and produce chalk. Lime is therefore exposed in an atmosphere of the gas, and the increase in weight determined; it is eventually ascertained that the lime increases in weight to the extent required on the assumption that it is reconverted into chalk; and on examining the product it is found to behave as chalk both when heated and when dissolved in acid. Thus the problem is solved, and it is determined that chalk-stuff consists of lime-stuff and chalk-gas. I employ these terms advisedly, and advocate their use until a much later stage is reached, when systematic nomenclature can be advantageously made use of.

In talking about chalk, it may be pointed out that chalk is believed to consist of skeletal remains and shells of sea-animals; and, when the composition of chalk has been ascertained, the suggestion comes naturally to examine shells. When their behavior on burning and towards acid is studied quantitatively, results are obtained which place it beyond doubt that they essentially consist of chalk-stuff. The chalk studies thus become of very great importance, and may be made to cover a wide field.

It is not to be denied that there are difficulties connected with such teaching as that I am advocating, but it is a libel on the scholastic profession to assert that the difficulties are insuperable. I am sure that in this case the old ever-true saying may be quoted, "Where there's a will there's a way." Such teaching has not yet been given simply because there must be less class-teaching, more individual attention, an adequate proportion of the school time must be devoted to the work, and properly trained, sympathetic teachers must be called in to give such instruction.

When scientific method is taught in schools, there will inevitably be a great improvement in school-teaching generally; it will be carried on in a more scientific manner, and new methods will be introduced. Indeed, I have already learned from a head master in whose school experimental science-teaching is receiving much attention, that the leavening effect on the teachers of some other subjects in the school is quite remarkable, and that they are clearly being led to devise more practical modes of teac

Photography and the lantern, also, are modern weapons of great power, which often enable us to clothe the dry bones of otherwise unattractive subjects with pleasing drapery. And here the parent can often intervene with great effect.

[Prof. Armstrong, in conclusion, drew attention to several "logs" kept by young children, illustrated with photographs, and insisted on the educational value of such work, owing to the opportunity which it afforded of directing attention to various matters of interest, and of impressing useful information on the memory.]

NOTES AND NEWS.

MR. E. M. JOHNSON, a graduate of the State School of Mines at Rolla, has been appointed to a position as aide on the Missouri Geographical Survey.

— Mr. T. H. Cornish of Penzance has a note in the current number of the *Zoölogist*, according to *Nature*, on some remarkably large catches of fish on the Cornish coast. On March 18 last, 12,000 gray mullet (*Mugil capito*) were captured, by means of a draw seine, by the fishermen of Sennen Cove, at Whitsand Bay, Land's End. The fish were of fine quality, one being brought to Mr. Cornish which measured two feet in length, one foot three inches in girth, and weighed six pounds ten ounces. On the 31st of the same month a Lowestoft mackerel driver, fishing some leagues south-west of the Lizard, took 48,000 mackerel. No such catch of mackerel, for one night's fishing, had ever been heard of before at Penzance, and what makes it more extraordinary, says Mr. Cornish, is that it should have taken place in March, when the catches usually average a few hundreds only. Later on in the season, in the fishing west of Scilly, 20,000 to 25,000 is regarded as a heavy catch.

— The preliminary returns of the recent census operations in India, says *Nature*, show that the population in British territory is 220,400,000, as against 198,655,600 in the former census, an increase of nearly 22,000,000. The Feudatory States, omitting incomplete returns, which may be taken at about 90,000, have a population of 61,410,000, making a total of 281,900,000, as against 250,700,000 for the same areas at the last census. The returns give Bombay 806,000, Madras 449,000, Calcutta municipal area and port 674,000, and including the suburbs Howrah and Bally, 969,000. At the last census the total for the same area was 847,000. Calcutta municipal area shows an increase of 92,000, and Howrah and Bally an increase of 24,000. The returns from Burmah show that the population of the whole country, excluding the Shan States, is 7,507,063, or 48.8 persons to the square mile. The population of Lower Burmah alone is 4,526,432, or an increase of about 790,000 since 1881.

— The American Academy of Political and Social Science has just issued its first handbook, containing the Constitution, names of officers, report of the executive committee for the first year, and the list of members. Although in active service only twelve months, it now has a membership of 1,978 gathered from every State and Territory in the Union, and from ten foreign countries. The membership in the United States is widely scattered. California, for example, is represented by 25 members; Massachusetts, by 195; New York, by 200; Illinois, by 150; while Canada on the one hand, and our Gulf States on the other, have 20 and 40 respectively. There are over 50 members in England, besides several in Scotland and Ireland. France is represented by 4; Germany, by 16; Russia, Switzerland, Austria, Italy, and even Japan and India, contribute to the academy's membership. The varied character of the occupation of the members also testifies to the great interest which economic and political subjects are exciting at present in the public mind. Among the members are leading representatives of all professions and branches of business.

— The English Meteorological Council have just published an atlas of cyclone-tracks in the South Indian Ocean, from information collected by Dr. Meldrum of Mauritius, during a period of thirty-eight years, from 1848 to 1885 inclusive, with the exception of three years for which no reports of cyclones were received. According to *Nature*, the tracks are represented in two sets of charts, — one set showing the distribution in each year; and the other grouping the storms according to months, excepting for August and September, in which months no cyclones were recorded. In dealing with these cyclones, Dr. Meldrum has divided them into progressive and stationary. It is admitted, however, that some of the latter may have moved, but that their progress may not have been detected from lack of observations. The relative frequency of both classes of storms for the whole period is very small, varying from one in eighteen years for July, to five in three years during February and March; but, although the number of storms is so small, it does not appear likely that many have been missed, considering the untiring persistence with which Dr. Meldrum has pursued his investigations. The tracks of the several cyclones will afford much valuable information, and lead to a better knowledge of the latitude in which the recurvature of the storms in that ocean takes place. A cursory examination shows that the range of latitude over which the points of recurvature extend varies considerably, being from about 15° to 25° south.

— The trustees of the Indian Museum, Calcutta, have issued an interesting and instructive report, by Mr. E. C. Cotes, on the locust of north-western India (*Acridium peregrinum*). The report, as quoted in *Nature*, sums up the results of an investigation conducted in the entomological section of the museum. It seems to be established that most of the flights of this locust issue from the region of sand-hills in western Rajputana. Others, however, invade India from breeding-grounds which probably lie along the Suliman Range, or even, perhaps, in some cases, beyond India's western frontier, in the sandy deserts of Baluchistan, southern Afghanistan, and Persia, though reports received from these regions, Mr. Cotes says, are so fragmentary that no very definite conclusions can be formed from them.

— The Meteorological Department of the Government of India has published Part 3 of "Cyclone Memoirs," containing an elaborate discussion of the two most important storms in the Bay of Bengal during the year 1888,— viz., those of Sept. 13–20 and of Oct. 27–31,— and also of the cyclone in the Arabian Sea of Nov. 6–9, 1888, accompanied by tables of observations during and before the storms and by 29 plates. The following (*Nature*, April 30) is a very brief *résumé* of some of the more important conclusions arrived at by Mr. Eliot with regard to these storms, and with regard to cyclones generally in India: (1) that the difference of intensity in different quadrants is chiefly due to the fact that the humid winds which keep up the circulation enter mainly in one quadrant; (2) that the ascensional movement is usually most vigorous in the advancing quadrant, a little distance in front of the centre; (3) in consequence of this, and of rainfall taking place most vigorously in front of the cyclone, the isobars are oval in form, and the longest diameter coincides approximately with the direction of the path of the centre (this is not in the middle of the diameter, but at some distance behind); (4) that the cyclonic circulation cannot be resolved into the translation of a rotating disk or mass of air, and that its motion is somewhat analogous to the transmission of a wave; (5) that the direction of advance of these storms is mainly determined by rainfall distribution, and there is a marked tendency for storms to form in and run along the south-west monsoon trough of low pressure; (6) the lie of this trough depends upon the relative strengths and extension of the two currents.

— Among the contents of the current number of the *Journal of the Straits Branch of the Royal Asiatic Society*, as we learn from *Nature*, is a paper on the *Sphingidæ*, or hawk-moths, of Singapore, by Lieut. H. L. Kelsall, R.A.. Mr. H. N. Ridley contributes papers on the *Burmanniaceæ* of the Malay Peninsusa; on the so-called tiger's milk, "Susu Rimau," of the Malays; and on the habits of the red ant, commonly called the *Caringa*. These ants, although very ferocious, are remarkably intelligent; and Mr. Ridley gives a striking account of the way in which they make leaf-nests. They have also great courage, and do not scruple to attack any insect, however large. Mr. Ridley once saw a fight between an army of *Caringas*, who tenanted the upper part of a fig-tree, and an advancing crowd of a much larger kind of black ants. The field of battle was a horizontal bough about five feet from the ground. The *Caringas*, standing alert on their tall legs, were arranged in masses, awaiting the onset of the enemy. The black ants charged singly at any isolated *Caringa*, and tried to bite it in two with their powerful jaws. If the attack was successful, the *Caringa* was borne off to the nest at the foot of the tree. The red ant, on the other hand, attempted always to seize the black ant and hold on to it, so that its formic acid might take effect in the body of its enemy. If it got a hold on the black ant, the latter soon succumbed, and was borne off to the nest in the top of the tree. Eventually the *Caringas* retreated to their nest. The last to go had lost one leg and the abdomen in the fight; nevertheless,

Mr. Ridley saw it alone charge and repulse three black ants one after the other before it left the field.

— The establishment of the Wharton School of Finance and Economy as a department of the University of Pennsylvania in 1881, marked an epoch in American higher education. Mr. Joseph Wharton, one of the most successful business-men of Philadelphia, believing most thoroughly in the desirability of a higher education for business-men, and seeing in the business world about him but few college-trained men, determined to see whether a course might not be arranged which would appeal to this class. With this end in view, he gave the University of Pennsylvania $100,000, on condition that it would establish and maintain a course in finance and economy for the benefit more especially of those youth who expect to enter business careers. The curriculum was made up of two parts, — a liberal and a practical. The latter consisted of accounting, mercantile laws and practice, the organization and management of various industries, etc. The former was made up of American history and politics, European history and politics, political and social science, statistics, etc. The liberal elements in the course attracted many young men who had no idea of going into business, but wished the thorough training in history and politics which this course afforded. As a result, the students of advanced classes, who expected later to study law or go into journalism, or to teach history and political science, chose this course by way of preference. The school is only ten years old, and consequently cannot point to its alumni by the hundreds or thousands; but the dinner given to Mr. Wharton by the alumni and their friends on May 19 in Philadelphia bore ample evidence of the success which the school has attained. The new curriculum has produced a visible effect already on other American colleges. The new university at Chicago proposes to have a college of practical affairs, which will be in essence a reproduction of the Wharton School; while the Stanford University, in California, will attempt an even more ambitious scheme along this line.

— In the improvements in contemplation at the University of Pennsylvania, the plans for which are now under way, two of the needs of the university which have lately made themselves strongly felt will be provided for. One is the necessity of improving the heating and ventilation of existing buildings and providing for that of new buildings. The other is the need of providing for the growing demands of the Department of Mechanical Engineering. Heretofore each building has been heated by a separate plant in its basement, and has been lighted by gas. It has been decided to build a central heating-station, with a present boiler capacity of 1,200 horse-power, from which to heat all the buildings, at present eleven in number. In addition, the buildings are to be lighted throughout by electricity, and to be thoroughly ventilated by the use of large ventilating fans in the basement, which are to be driven by steam or electric motors; while the ventilating flues in the old buildings are to be changed to accord with the best modern practice. The engines and dynamos for this purpose are to be placed on the ground floor of a separate building, the two upper floors of which will be used by the Mechanical Engineering Department. These two buildings are so designed that additions may be made to them as need arises. The entire plant is to be put in, not only for the purpose of furnishing light and heat in the most economical manner, but, in addition, it is designed especially for the purpose of instruction, for which it will at all times be available.

— The Kentucky Experiment Station is located at Lexington, in the heart of the blue-grass region, and on a soil which has been formed from the decomposition of the underlying limestone rocks. On this soil potash has seemed to be the most needed element of a fertilizer for corn and potatoes, although it has not produced so marked an effect on wheat. Bulletin No. 33 of this station reports a series of experiments in applying fertilizers to corn, of which the following is the station's summary: "The results obtained this year are almost identical with those of the last two years; that is, first, that, in those plots where potash was one of the ingredients of the fertilizers used, there was a marked increased yield, both in corn and fodder; second, that in plot 15, where a fertilizer was used without potash, there was scarcely any increase in yield over those plots containing no fertilizer; third, that the greatest increased yield was made by using a combination of potash and nitrogen; fourth, that the use of muriate of potash alone resulted in a marked increased yield over the plots containing no fertilizers; fifth, that there was a profit in the use of fertilizers in every instance where potash was one of the ingredients, the largest net profit arising from the use of the mixture of nitrate of sodium and muriate of potash; sixth, that there was a loss by the use of fertilizers where potash was not one of the ingredients; seventh, that so far, potash fertilizers have shown their effect the third season after application." The Ohio station has been conducting similar experiments to those reported above, both on its farm in Columbus and on several other farms in different parts of the State; but the results differ from those of Kentucky in that no combination of fertilizers has produced a sufficient increase of crop to pay for the cost of application. In only one place has potash produced any marked effect in Ohio, and that was in Butler County, on a soil that is probably largely derived from similar rocks to those which have formed the blue-grass soil.

— In his monthly report for April, Mr. Arthur Winslow, State Geologist of Missouri, states that field-work during that period had been actively resumed. Examinations of clays and structural materials had been made in Franklin, Montgomery, Audrain, Warren, and St. Charles Counties, and the experimental work on the clays had progressed well. Examinations of coal deposits had been extended into Clinton, Caldwell, Linn, Schuyler, Adair, Sullivan, and Boone Counties. Detailed mapping was begun in Ray and Madison Counties, and about fifty square miles have been covered. Bad weather and the water-soaked condition of the country had, however, interfered with the progress of this work. Examinations of mineral waters had been made in St. Louis, Jefferson, Perry, Madison, Wayne, Laclede, Howell, Oregon, and Barry Counties, and samples had been carefully collected for analysis. Work on the zinc and lead deposits of the southern portion of the State has been resumed by the United States Geological Survey in co-operation with the State Survey. About the middle of the month a party of the Coast and Geodetic Survey, in charge of Mr. Isaac Winston, began the work of extending a line of precise levelling from Jefferson City westwards. This line was brought as far as Jefferson City several years ago, and is now extended in accordance with an application made by the State Survey to the superintendent of the Geodetic Survey. In the preparation of the report on the paleontology of the State good progress has been made, and several other reports are in course of preparation.

— A committee of the Appalachian Mountain Club has made arrangements for the free exhibition of the geographical collection of the Brooklyn Institute in Boston. The Winslow Skating-Rink has been secured for the exhibition for three weeks, May 11 to May 30. The collection includes all varieties of geographical appliances, chiefly for educational purposes, such as wall-maps, atlases, globes, models, views, diagrams, text-books, etc. It is comparable to the collection made by the Royal Geographical Society, and exhibited in London a few years ago. The materials have been given to the institute by all the leading publishers in this country and Europe. The collection was on free exhibition in Brooklyn during March, and was visited by about 30,000 persons, including many teachers with their classes. It is designed for exhibition in various cities before final incorporation in the museum of the Brooklyn Institute. The University Extension Society of Philadelphia, the Johns Hopkins University of Baltimore, and the National Geographic Society of Washington, are in correspondence with the institute with the intention of securing the collection in their respective cities. The collection has been carefully examined, and is deemed well worthy of attention from those interested in general education. It will be found suggestive to teachers from the large variety of materials that it includes; it will promote an interest in the study of geography among the pupils in our schools; it will prove of value to superintendents and principals of schools in giving opportunity for comparison of a large variety of maps, text-books, etc.; it will be attractive to the intelligent public generally.

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OUR PRESENT KNOWLEDGE OF THE HIMALAYAS.[1]

THIS was the subject of an able paper read at Monday's meeting of the Royal Geographical Society, by Col. H. C. B. Tanner (Indian Staff Corps), who for many years has been one of the officers of the Indian Survey, most of his time having been spent in various parts of the Himalayas from north-west to south-east. The paper was illustrated by a large number of admirable drawings by the author, which afforded an excellent idea of the physical and picturesque aspects of this great mountain system.

With regard to avalanches, Col. Tanner stated that they play a great part in the conformation of the topography, — a greater part, indeed, than is generally supposed, — and this factor has not received the attention it deserves at the hands of geologists.

"I became acquainted," he said, "with four distinct kinds of avalanche, which, perhaps, are called by distinctive names by mountaineers, though I have been unable to ascertain them. The first, and the most common, is the precipitation of a mass of new snow from slopes which, from their steepness, are unable to retain more than a limited quantity of snow on them. They occur generally in winter and in early spring, and are the cause of the results just described. The second kind of avalanche is a descent of *old* snow, which is loosened by the heat of the sun. They may be heard throughout the summer and autumn, and are dangerous from the unexpected and irregular manner in which they slide off. The sportsman and traveller should guard against them by intelligently placing his camp in some sheltered spot out of their reach. This class is not usually of any great extent or weight, but such avalanches are of constant occurrence. The third kind can only be seen when the mountains are of peculiar formation or structure, and are really ice and not snow avalanches. They are of very constant occurrence in some localities, more particularly where small glaciers are situated high up on the crest of mountains, and are gradually pushed over the edge. In Lahaul, in the company of a friend, we watched the face of the well-known Gondla cliffs from the right bank of the Chandra River, and saw a number of these ice-falls, which came down every few minutes, filling the air with the noise of the loosened rocks and ice-blocks. The fourth kind of avalanche is one that I have only once seen, and have never known described. It is very curious, being the movements of billions of snowballs, which, in a stream a mile or half a mile long, I saw slowly wind down the upper part of an elevated valley in the Gilgit-Dareyl Mountains. I was after *Ibex* at the time of the occurrence, and was watching a herd of these animals, when I became aware of a low but distinct and unusual sound, produced by a great snake-like mass of snow winding down one of the valleys in my front. It occasionally stopped for a moment, and then proceeded again, and finally came to a rest below me. I found this curious movement of snow was produced by countless numbers of snowballs, about the size of one's head, rolling over and over each other. The torrent-bed was full of them, — an accumulation formed by numerous similar freaks of nature. I am quite unable to account for such an avalanche as the one now described. How does it originate, or by what process is the snow rolled up into these innumerable balls?"

Col. Tanner made some interesting remarks on the subject of the line of perpetual snow. "Various authorities," he stated, "lay down such a line with great assurance; but for myself, I find that circumstances of position, of climate, and of latitude, play so great a part in the position of this line that I am unable to define it even approximately. No sooner in one locality, or during one particular season, have I settled, to my own satisfaction, the line of perpetual snow, than I presently have been obliged completely to modify my views on the subject. On p. 124 of the 'English Cyclopædia,' vol. v., I read that snow lies 4,000 feet higher on the northern than on the southern side of the Himalayas. On p. 281, vol. x., of the same work, it is stated that the snow-line on the northern slope is at 19,000 feet, which I should have been inclined to say is 1,500 or 2,000 feet too high. In Gilgit, during the end of summer, I found masses and fields of snow at 17,200 feet; and they extended down the northern slope certainly 2,000 feet, or even more, below that altitude. In Kulu, which has many degrees of latitude less than that of Gilgit, avalanche snow lies in valleys above 8,000 feet throughout the year after a good winter snowfall; but during the past spring, following a very mild winter, I found no snow at all at 8,000 feet. There had been no avalanches, and even in June, at 14,000 feet, snow lay only in patches. I think, that, in determining the snow-line with greater precision than has been done hitherto, scientific men should ascertain those altitudes on which perpetual snow lies on flat places in the position where it first falls, and should neglect the occurrence of a snow-field where it may have been protected from the sun's rays by its occurrence on the north face of a mountain. From memory I can state that there are a considerable number of typical localities which would help out such an inquiry. There is a peak (without a name) about thirty miles north of Gilgit, with rounded summit, which, though only 17,500 feet high, is covered with a cap of perpetual snow."

Speaking of the Himalayan glaciers, Col. Tanner stated that the most extensive and the most picturesque he has seen are in the Sat valley, which drains the southern face of Rakaposhi Mountain in Gilgit. Three great glaciers come down into this valley, and dispute with the hardy mountaineers for the possession of the scanty area of the soil. Here may be seen forests, fields, orchards, and inhabited houses all scattered about near the ice-heaps. The only passable route to the upper villages in this valley crosses the nose of the greatest of the three glaciers, and threads its way over its frozen surface. This glacier is cut up into fantastic needles of pure green ice, some of which bear on their summits immense bowlders. About half a mile from its lower end or nose, Col. Tanner found an island bearing trees and bushes, and at one place above this a very considerable tarn of deep blue-green water. The glacier had two moraines parallel with each other, and both bearing pine trees; and, from the highest point Col. Tanner reached, he fancied he saw the ice emerging from the *névé* at its source, far away up the slopes of Rakaposhi. In this glacier the pinnacles, wedges, blocks, and needles of ice were of the most extraordinary appearance, and the whole formed a weird and impressive view which he can never forget. Though the largest glacier Col. Tanner has ever approached, it is very small indeed when compared with those described by Col. Godwin-Austen in a locality not very far from the Sat valley. Insignificant though it is, it was more than Col. Tanner could take in during his visit of two days' duration. It struck him at the time of his inspection that the peculiar stratified appearance of the ice needles, which in the case of the Sat glacier is very strongly marked, must have been caused by the different falls of avalanche snow on the bed of *névé* at the source of the glacier.

[1] From Nature of April 30.

The lowest glacier Col. Tanner has seen in the Himalayas is one that reaches the foot of the range near Chaprot Fort in latitude 35½°, in Gilgit. It is formed of beautiful clear ice, and has no dirt. In Kulu and Labaul (latitude 32°) glaciers do not come down below 12,000 or 13,000 feet, and all are very dirty; and in Sikkim (latitude 28° or 29°), without having visited the glacier region himself, Col. Tanner would say that the lowest limit reached by the Kinchinjanga group must be considerably higher, perhaps by 2,000 feet or even more. The smallest mountain he has ever met with, capable of giving rise to a glacier, is one on the Gilgit-Dareyl range, whose height is 17,000 feet; and in this case the mass of ice formed is of very inconsiderable size. Of the glaciers round Mount Everest and its great neighbors, we know next to nothing; and the little we have learned is derived from the itineraries of native explorers, who, of all classes of travellers, seem the least capable of furnishing trustworthy information regarding any subject lying at all outside their actual angular and distance measurements. But with his telescope, when employed on the survey of the Nipal boundary, Col. Tanner has gazed long and earnestly at the icy regions at the foot of Everest, and Peak No. XIII., where the glaciers extend over a very large area.

With regard to our actual knowledge of the Himalayas, Col. Tanner thinks that perhaps our botanical knowledge is far ahead of other branches of science. Many eminent botanists have been at work for a long time past, and of late Dr. Duthie has been allowed to travel on duty into tracts not before visited by any one possessing the requisite knowledge. It is likely that Dr. Duthie's museum at Saharunpur will, within a moderately short time, become an almost complete depository of the chief vegetable products of the Himalayas. The geologists, Messrs. Blandford, Edwin Austen, Richard Strachey, Stolitzka, and Lydekker, have been pretty well over those tracts open to Europeans, and are now well acquainted with all the leading features of their branch of science presented by the mountains of Kashmir, Kumaon, Kangra, and Sikkim. Ornithology has found many votaries, and the birds of these mountains are now probably all or nearly all known, though the late Capt. Harman, only a few years back, discovered a new and handsome pheasant in the extreme eastern end, either of Bhutan or Thibet. The mammals, Col. Tanner supposes, are all known, though one, at least, the Shao, or great stag of Thibet, has not even been seen by any European, and the famous *Ovis poli* has been shot by not more than two or three sportsmen.

With regard to the work of the survey, Col. Tanner stated that the maps of Kashmir and Gilgit, without being free from error, are of the greatest use to a large class of officials. Incomplete though they may be, they were not brought up to their present state without taxing to the utmost the endurance of a hardy set of men. Adjoining Kashmir to the eastward comes Kangra, with its subdivisions of Kulu, Lahaul, and Spiti. Kangra had once been roughly surveyed prior to the arrival there of Col. Tanner's party, who are now at work on a very elaborate contoured map, which will take a long time to complete, owing to the intricacy of the detail demanded. Between Kangra and Kumaon occur various native states whose territories are being surveyed on the scale of two inches to one mile, also contoured work, resulting in very elaborate and trustworthy, though somewhat expensive, maps. Eastward of Kumaon, Nipal stretches along our border for some five hundred miles till Sikkim is reached; and eastward again of Sikkim comes Bhutan, and various little-known and semi-independent states which lie on the right bank of the Sanpo River. Nipal marches with the Kumaon border for many miles, and advantage was taken of the existence of the trigonometrical stations on the Kumaon hills to extend our knowledge of the adjacent topography of Nipal, and this was done about four years ago with some little result. The more prominent peaks in Nipal within a distance of about one hundred and sixty miles were fixed trigonometrically, and some slight topographical sketching was done. From the trigonometrical stations near the foot of the lower hills, both in the North-West Provinces and in Bengal, trigonometrical points have lately been fixed, and some distant sketching done in Nipal, for five hundred miles between Kumaon on the western, and Sikkim on the eastern, extremity of this kingdom; and, again, from the trigonometrical hill stations along the western boundary of Sikkim more points and hazy topography of Nipal was secured. This very meagre topography, sketched from very great distances, comprises all the geography of Nipal other than the sparse work collected by Col. Montgomerie's explorers, or by explorers trained to his system who have worked since his death. All the existing data, whether trigonometrical, distant sketching, or native explorers' routes, are now being combined, as far as the often conflicting and contradictory materials admit. The resulting map of the country, though at most little better than none, is all we have to expect until some of the strictures on travelling in Nipal are lessened by the Nipal Government.

The whole of the Nipalese border, which marches with British territory for some eight hundred miles, is jealously guarded, and no European is allowed to cross it, except when the Resident of Kashmir, or his own personal friends, are permitted to proceed by a certain and particular route, between the military station of Segowli and Katmandu. Sikkim flanks the eastern boundary of Nipal, and the, until lately, indefinite western boundary of Shutan. British Sikkim is a small tract, which has twice been surveyed on suitably large scales. Independent Sikkim, which contains Kinchinjangee, one of the highest mountains, and some famous passes, — the Donkhya, visited by Sir Joseph Hooker and a few others; and the Jelap, where our forces, under Gen. Graham, have lately been employed, — was surveyed in reconnaisance style by Mr. Robert, an energetic and hardy assistant of the Survey of India Department. The sketch-map obtained by this gentleman is complete, and similar in character to that of Gilgit by Col. Tanner, and to that of Nari Khorsam and Hundes by Mr. Ryall. It does not pretend to any exhaustive detail.

Our knowledge of Bhutan, or, rather, our ignorance of it, is about on a par with that of Nipal; but in Bhutan we have the valuable information left by Capt. Pemberton, who forty-three years ago traversed the greater portion of the country from west to east. Besides Pemberton's work, Col. Godwin-Austen, while he accompanied Sir Ashley Eden's mission to the court of the Deb Raja in the year 1863, executed a route-survey in western Bhutan. The engineer officers who were attached to the military force at Pewangiri also did some little topographical sketching; and beyond this we have distant sketching and trigonometrical work, as in Nipal, which also has yet to be combined with the route-surveys of native explorers, some rather recent, and some of greater date. The difficulties which are presented to further researches in the direction of Bhutan geography seem unlikely to diminish. Our knowledge, then, of Bhutan is as unsatisfactory as that of Nipal. Eastward of Bhutan occur those numerous semi-independent hill-states which sometimes, when necessity presses, own allegiance to Thibet, and at others assert their complete freedom from control. Col. Tanner himself has sent in two maps of this region derived from native sources, and both upset maps previously accepted, and it is highly improbable that we have any but the most rudimentary and vague knowledge of the course of the Sanpo below Gyala Sindong, and not even that of the course or limits drained by the Dibong. Col. Tanner then referred in some detail to the great rivers that have their sources in the Himalayas, and concluded by giving some advice to tourists as to the best routes to take.

BANANA PRODUCTION.

THE banana industry, which, according to the "Handbook of the American Republics," was only commenced in 1883, is becoming more and more important every day. The bananas, which grow spontaneously in the tropical countries, have been from that date an article of commerce. Formerly they were planted in the coffee plantations to shade the young trees and shelter the grains from the wind that would sweep down the unmatured berry. The fruit of the banana was used to fatten pigs, or grew without any cultivation in the mountains and plains, thus going to absolute waste. Bananas principally come from the British West Indies, Cuba, Honduras, Costa Rica, Nicaragua, Guatemala, British Honduras, Colombia, Hawaiian Islands, and Salvador.

The lands chosen for the production of the bananas are those

that contain extensive alluvial deposits, composed chiefly of blue clay impregnated with marine salt, and rich in decomposed vegetable matter. On large plantations the trees are usually planted from twelve to fifteen feet apart, in the form of squares, and where irrigation is required, trenches are dug between them to admit the water passing through as often as it is necessary. In places where the rain is abundant, or where the soil is damp, the bananas grow best. It is generally at the end of nine months that the plants mature, and after that time the fruit can be gathered every week in the year, provided the plantation has been well kept, and has had a good start. At that time the trunk of the tree attains a height of eight or ten feet, and a girth of about thirty-six inches. From the trunk, which is porous and yields an excellent fibre, palm-like branches are thrown out to the number of six or seven. The bunch of fruit appears at the juncture of the trunk and branches, and consists of from four to twelve of what are termed "hands," each hand having eight to twelve bananas on it. A bunch of eight hands or clusters is counted as a full bunch; while those that have from five to seven are taken as a half bunch; bunches not less than five hands are styled third class, the others respectively first and second class. From the root of this tree several shoots or suckers sprout, each of which in turn becomes a tree, and bears a bunch of bananas, or they may be transplanted. After a bunch has been cut, the tree is usually felled; in fact, the tree is more frequently cut to gather the fruit. The manner in which the banana is cultivated is most easy, as very little skill or labor is demanded, nature doing almost all the work.

LETTERS TO THE EDITOR.

**** *Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

The editor will be glad to publish any queries consonant with the character of the journal.

On request, twenty copies of the number containing his communication will be furnished free to any correspondent.

Origin of the Galapagos Rookeries.

IT is generally supposed that animals now living in latitudes bordering the polar circles are naturally confined to the cool regions of the earth, and such is usually the case; but there are some remarkable exceptions to this rule. Such, for instance, are the rookeries of albatross, fur seal, and penguin at the Galapagos Islands.

That this equatorial group of islands is inhabited by a fauna usually confined to the high latitudes has long been known to Pacific navigators, and also to such celebrated naturalists as Darwin and Agassiz, who visited them years ago. Still, there seems to be no satisfactory explanation offered to show why the fauna of the cold latitudes should now exist at the equator.

It may be that neither of the above naturalists, while having knowledge of the rookeries of hair seal, knew that a small rookery of fur seal made its home under the almost inaccessible cliffs of Abingdon, or that albatrosses had their hatching place on the shores of Hood's Island, or that a small species of penguin frequented the shores of Albemarle.

Under the present climatic conditions of our globe, it is not likely that the fauna of the cold regions would have selected breeding places under the equator, especially when such rookeries are so far removed from their normal home in the high latitudes. As their inhabitants are never seen far from the land of birth, I for many years after my first visit to these islands was unable to supply myself with a satisfactory solution of the problem. I at first thought that the albatrosses may have made the passage from their tropical rookery to the high latitudes through the upper atmosphere, which their great power of flight would enable them to accomplish. But I have since come to the conclusion that the Galapagos rookeries are the relics of a frigid period, and that their progenitors sought out these seemingly unnatural breeding places at a time when the climate of the Galapagos was much colder than now.

When we consider the low temperature which the eastern Pacific waters must have possessed during the ice-age, when the lands of southern Chili, and the shores of North America as far south as Oregon, were launching icebergs into the sea to be floated directly towards the Galapagos by the prevailing ocean currents, we can conceive how during such a frigid age the fauna of the high latitudes found a fitting home within this portion of the tropics. And it is owing to the ocean currents which still move from the high latitudes along the North and South American coasts, and cool the Galapagos seas, and also to the strong attachment of such species of life for their breeding places, that they have been able to continue, a feeble remnant, until the present century. Moreover, the isolated situation of the Galapagos may have aided, at the close of the ice period, to prevent the abandonment of the rookeries for a more congenial latitude. The nearest lands now suitable and occupied by such species of animals, as before stated, are situated in the high latitudes, thousands of miles distant from the Galapagos, while the wide intervening seas afford no signs of the albatross, seal, or penguin; and it is the opinion of seamen who are acquainted with the Galapagos rookeries that their occupants are confined to the seas of that region.

The rookeries of sea-lions found on these islands, and so well described by Mrs. Agassiz, are also far removed from the usual breeding places of such animals, the sea-lions of California being their nearest neighbors.

The large tortoises which inhabit the Galapagos, and from which the islands derive their name, probably emigrated at an early date from the American coast, which is some four hundred miles distant; for I have noticed that they appear quite at home in the water.

The progenitors of the terrestrial iguanas found on Albemarle, probably lived in the ocean in the remote past, according to Darwin's opinion, and are consequently related to the sea iguanas which abound in those waters. C. A. M. TABER.

Wakefield, Mass., May 16.

BOOK-REVIEWS.

A Journal of American Ethnology and Archæology. Edited by J. WALTER FEWKES. Vol. I. Boston and New York, Houghton, Mifflin, & Co., 1891.

Report of the Proceedings of the Numismatic and Antiquarian Society of Philadelphia for the Years 1887–1889. Philadelphia, printed for the society, 1891.

THE *Journal of American Ethnology* is scarcely such in the usual acceptance of the term. Its whole contents consist of three papers by the editor, all of them from his notes when connected with the Hemenway South-western Archæological Expedition. The first is entitled "A Few Summer Ceremonials at Zuñi Pueblo," principally descriptive of various dances. The second is on "Zuñi Melodies," the notes of which were obtained by Dr. Fewkes on phonographic cylinders exposed to the singing of various members of the Zuñi tribe, and subsequently taken down from the hearing with the aid of a harmonium. The instrumental study of the melodies is the work of Mr. Benjamin Ives Gilman, and is admirably presented. The third paper, accompanied with a map, describes a "Reconnoissance of Ruins in or Near the Zuñi Reservation." These ruins are those of the former residences of the Zuñi tribe, and are eighteen in number, though the reconnoissance is not asserted to embrace all that remain.

The *Journal* is admirably printed, well-illustrated, and full of excellent original material, although its title seems a misnomer.

The volume of proceedings of the Numismatic and Antiquarian Society of Philadelphia, edited by its efficient secretary, Mr. Stewart Culin, contains the usual lists, etc., and seven original papers, of all of which we can speak in terms of praise. One is by Mr. Culin himself, on a curious secret society among the Chinese in America, and two are by the Rev. Dr. W. M. Beauchamp, on the Onondagas and the early medals, crosses, rings, etc., found among them. Mr. B. S. Lyman, a high authority on all Japanese matters, describes an old Japanese standard foot measure; Mr. Frances Jordan, jun., speaks of aboriginal American wood-working; and the president of the society, Dr. Daniel G. Brinton, contributes a study of the character of American aboriginal poetry, and also an interpretation of a celebrated rock-inscription near Orizaba, Mexico, called "The Stone

of the Giants." Besides these, a number of abstracts of other papers are given. The volume is illustrated with numerous engravings, and is issued in creditable style. The society is to be congratulated on this evidence of its prosperity.

The Old Navy and the New. By REAR-ADMIRAL DANIEL AMMEN. Philadelphia, Lippincott. 8°. $3.

IN these days of the new navy we are apt to forget the old-timers, and all that they did to build up a solid foundation and educate the younger officers, so that the modern vessels can in their turn be models of efficiency as the wooden craft were. In this work the author tells a plain story of events, at home and abroad, just as he found them; and although he had no very startling adventures to punctuate his active career, there are many valuable lessons for officers about starting out for a naval life. The excellent habit of keeping a diary here bears good fruit, as the main dependence has quite evidently been placed upon notes taken at the time, with an occasional "freshening of the nip" by reference to official logs kept on board the vessels and afterward turned in to the navy department.

Among other points worthy of note are the meeting for the first time with men-of-war fitted with steam machinery, rifled guns, and other modern improvements of the day. The idea of the life-raft, or "balsa," which now forms an important feature in the outfit of vessels of war as well as passenger steamers, and for which thanks are largely due the author, seems to have struck him quite early in life. The efficiency of the ram as a fighting factor also impressed itself upon the admiral years ago, and the outcome is the modern ram that is now building for the navy.

The experience gained while on duty in the coast survey, and at the naval observatory, enabled the admiral, while chief of the Bureau of Navigation, to have carried on some very scientific work in relation to determining longitudes by telegraphy, and also surveys of the Isthmus, which latter are to-day resulting in the construction of the Nicaraguan Canal.

The former work by the same author, "The Atlantic Coast during the Civil War," so effectually covers the period of the Civil War that the present work unfortunately deals but slightly with the interesting events of that period. A very prominent feature of the book is the intimacy from boyhood that existed between the author and General Grant. The close of the volume contains some very interesting letters, which, among other things, show very plainly the very high regard and the warm friendship that the great hero of the war had for the admiral.

The book commends itself not only to professional men but to all who take a proper interest in the well-being of the navy.

AMONG THE PUBLISHERS.

AMONG the articles in *The Chautauquan* for June are, "The Intellectual Development of the English People," by Edward A. Freeman; "Hungary's Progress and Position," by Albert Shaw; "Studies in Astronomy, IX.," by Garrett P. Serviss; "The American Patent System," by Walter Hough; "Dr. Schliemann — The Excavator of Ancient Troy," by Thomas D. Seymour; "American Glass Workers," by F. M. Gessner; "Periodic Changes in Climate," by E. Richter; "The Latest Phases of Electricity," by Robert W. Prentiss; and "College Girls," by Kate Gannett Wells.

— "Philomythus, an Antidote against Credulity," Dr. Abbott's new book, is devoted to a discussion of Cardinal Newman's essay on ecclesiastical miracles. It will appear in a second edition, with a new preface, from the press of Macmillan & Co., New York.

— Mr. H. E. Haferkorn, Milwaukee, Wis., has published a translation, by Dr. Fr. Brendecke, of Koch's first communication to the *Deutsche Medicinische Wochenschrift* on the cure of tuberculosis. Explanatory notes have been inserted and the subject put into more popular shape by the editor, Dr. Max Birnbaum.

— D. C. Heath & Co., Boston, are just issuing "Comparative View of the Executive and Legislative Departments of the Governments of the United States, France, England, and Germany," by John Wenzel, assistant librarian of the College of Liberal Arts, Boston University. This consists of outlines of the four great constitutional governments, arranged in parallel columns in such a way that similar topics are grouped together. By this arrangement comparison can readily be made. Professor Woodrow Wilson of Princeton, the author of "The State," has examined the manuscript, and made suggestions and corrections.

— The seventh volume of the new edition of "Chambers's Encyclopædia," to be published in June by the J. B. Lippincott Company, will contain articles on "Mysteries," by Baring-Gould; "Cardinal Newman," by Hutton; and Mr. Blackmore discourses about orchards; Stanley Lane-Poole writes about "Mecca and Medina," Dr. Head on "Numismatics," Dr. John Murray on the "Pacific," and Canon Taylor on "Names." "Palestine" engages two contributors, Mr. Besant and Professor Hull.

— Certainly an entirely new departure in journalism is made in *The Engineering Magazine*, the first number of which appeared in April. This is not an addition to the numerous trade papers, but is intended to give each month, in untechnical language, articles by competent writers on engineering matters likely to interest the public. Such topics are: "Epidemics and Water Pollution," treated by George W. Rafter; "Danger Signals about the Boiler," by Robert Grimshaw; "The Rapid Transit Problem in New York," by T. Graham Gribble; "Building the Steamship in America," by Horace Lee; "The Tall Office-Buildings of New York," by John Beverley Robinson; "Our Old-Fogy Methods of reckoning Time," by Sandford Fleming; and "Splendid Record of the Electric Railway," by Frank J. Sprague. All these and more appear in the May number. The Engineering Magazine Company, World Building, New York City, are the publishers.

— The North Carolina Experiment Station has just issued a twenty-page bulletin (No. 76) on plant-diseases, by Gerald McCarthy, the station botanist, illustrated by eleven engravings showing the appearance of diseased plants and the best forms of spraying-apparatus. This bulletin contains a brief and pointed chapter on vineyard and orchard hygiene, and treats in full of the following diseases: rot, mildew, and anthracnose of the grape; peach-rot; black-knot of plum and cherry; apple, pear, and quince scab; leaf-blight of pear; fire-blight of pear; peach-yellows; potato-blight; rust of cereals; bunt of wheat; smut of oats; smut of corn; ergot of rye. This bulletin will be sent free to all names on the regular mailing list of the station, and to others within the State who apply for it. Only a limited number of copies will be available for distribution outside the State. These will be sent, so long as the supply lasts, to applicants who inclose six cents. Address North Carolina Experiment Station, Raleigh, N.C.

— Messrs. Fords, Howard, & Hulbert have published a small book by Amos K. Fiske entitled "Beyond the Bourn." It purports to give the experience of a man during a visit to the spirit-world, whither he was transported while he lay unconscious from a railroad accident. He meets his old friends in the spirit-world, who instruct him in the mysteries and the enjoyments of the life they lead. A considerable portion of the book, however, is occupied with the account of a visit which he and his spirit friends made to a planet far distant from the earth, but peopled by a race of beings similar to men, only in a more advanced stage of development. They are represented as living in a veritable Utopia, surpassing even Mr. Bellamy's; yet they have reached it by voluntary action and co-operation without any help from the State. The book is fantastic throughout, and for the most part shallow, and it sheds no light on the great subjects with which it deals.

— Some photographs of luminous objects (taken by their own light) will be reproduced in the June *Scribner* by mechanical processes, directly from the original negatives. All amateurs will be interested in the pictures, which show fireworks, interiors by lamplight, rolling-mills, electric discharges, sun-dogs, and other curious subjects. William H. Rideing (who has all his life been familiar with steamship affairs) contributes to the same number the third of the Ocean Steamship series, on "Safety on the Atlantic." He gives an account of the precautions and devices which have made ocean travel one of the safest methods of locomotion. He prints the following remarkable record for 1890: "Nearly two thousand trips were made from New York alone to

various European ports; about two hundred thousand cabin passengers were carried to and fro, in addition to nearly three hundred and seventy-two thousand immigrants who were landed at Castle Garden. This enormous traffic was conducted without accident, and no more comforting assurance can be given than this of safety on the Atlantic."

— In "The Compounding of English Words," a neat little volume, of which F. Horace Teall is author and John Ireland publisher, a praiseworthy attempt is made to show when and why the joining or the separation of certain words is preferable. Concise rules are given in relation to the use of the hyphen and the "solidifying" of separate words into one without the hyphen; also lists of words showing the author's preferences in these matters. "Preferences" they must necessarily be called, for, notwithstanding the many excellent reasons given for some forms of words, and other reasons not so good for other forms, the thousands of writers, printers, teachers, proof-readers, and others, to whom the book is dedicated, and to whose interests it appeals, will still continue to use their individual preferences, — and they mould that department of language, or rather, defy all attempts to have it moulded into any semblance of uniformity. While the author claims this to be the "first systematic attempt to disentangle the perplexities of English compounding," he gives due credit to Fowler, Wilson, and others, who have made some slight efforts in the same direction. The book will be of value to all whose work lies in its direction, whether they accept its conclusions or not; for it gives, in little space and convenient form, all, or nearly all, the words about which there are differences of opinion, with the reasons for the author's preferences of particular forms clearly stated.

— We have received from Ginn & Co. "A Higher Algebra," by G. A. Wentworth, professor of mathematics in Phillips Exeter Academy. The work gives in one volume a preparatory course for colleges and scientific schools, besides providing a sufficiently full treatment of the subjects usually read by students in such institutions.

— The fifth paper in the *Popular Science Monthly's* illustrated series on the development of American industries since Columbus will describe "The Manufacture of Wool." It will appear in the June number, and the writer is S. N. Dexter North, secretary of the National Association of Wool Manufacturers, and special agent of the Eleventh Census. In the same number appears the concluding part of Dr. Andrew D. White's paper on "Miracles and Medicine," and "Our Grandfathers died too Young," under which odd title Mrs. H. M. Plunkett describes the progress in sanitation which has doubled the average length of life in civilized countries within a few hundred years. Lieutenant-Colonel A. B. Ellis contributes an essay on "Survivals from Marriage by Capture." "The Pearl of Practice" is the title of a book of medical prescriptions, printed in London over two hundred years ago, some

Publications received at Editor's Office, May 11–19.

GETTING Married and Keeping Married. (Human-Nature Library.) New York, Fowler & Wells. 22 p. 12°. 10 cents.

GRAHAM, DOUGLAS. A Treatise on Marriage, Theoretical and Practical. New York, Vail (2d ed.). 342 p. 8°.

LETOURNEAU, C. The Evolution of Marriage and of the Family. New York, Scribner. 373 p. 8°. $1.25.

MICHIGAN, Seventeenth Annual Report of the Secretary of the State Board of Health of the State of, for the Fiscal Year Ending June 30, 1889. Lansing, Thorp pr. 324 p. 8°.

POSTAL Savings Banks. An Argument in their Favor by the Postmaster-General. Washington, Government. 72 p. 8°.

THORNTON, W. Origin, Purpose, and Destiny of Man; or, Philosophy of the Three Ethers. Boston, The Author. 100 p. 12°.

WENTWORTH, G. A. A Higher Algebra. Boston, Ginn. 521 p. 12°. $1.55.

extracts from which are embodied in an article by Miss Elizabeth Robinson to appear in the same issue. After reading the list of ingredients in some of these unsavory messes no one need wonder about the origin of the saying, "The remedy is worse than the disease."

— Arrangements for instruction in botany at the Marine Biological Laboratory have now been completed, and Mr. Setchell of Harvard University will again take charge of the work in this department. Applications for places in either department should be addressed to Miss A. D. Phillips, secretary, 23 Marlborough Street, Boston.

— Among the fifteen candidates recently selected by the council of the Royal Society (London) to be recommended for election into that Society is George Mercer Dawson, D.Sc., F.G.S., A.R.S.M., F.R.S.C., Assistant Director of the Geological Survey of Canada. His qualifications for membership, as summarized in *Nature* of May 7, are as follows: Much important and valuable work, more especially in geology and ethnology, as in the following summary statement. During his thirteen years of service on the Geological Survey (Canada) has been chiefly engaged in working out the geology of the North-West Territory and British Columbia; placed in charge of the Yukon Expedition, 1887; author of numerous papers, chiefly geological, but including geographical, ethnological, and other observations, published in the *Quarterly Journal of the Geological Society*, "Transactions Royal Society, Canada," *Canadian Naturalist*, etc. These deal more especially with the superficial geology of the regions explored, but some describe *Foraminifera* and other microscopic organisms. Author of fifteen reports published by the Geological Survey of Canada, and joint author (with Dr. Selwyn) of a "Descriptive Sketch of the Physical Geography and Geology of Canada," and (with Dr. W. F. Tolmie) of "Comparative Vocabularies of the Indian Tribes of British Columbia."